DROUGHT

AND ECONOMIC RESILIENCE OF OKLAHOMA

COUNTIES

By

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Abstract:

Understanding the impact of climate variability and economic resilience to extreme climate variability is essential to managing community resources and setting policy for Oklahoma. In this research, it has been hypothesized that community capitals play a vital role to make Oklahoma counties economically resilient to climate variability. A climate variability index is used to identify historical drought events across Oklahoma counties between 1996 and 2012. Economic resilience of Oklahoma counties is measured by economic decline and recovery during and after a drought period. Finally, proxies for seven types of community capital are used to explain the variance in the economic resilience of Oklahoma counties. This research has found that natural and financial capitals contribute to income resilience and cultural capital contributes to employment resilience of Oklahoma. On the other hand, political capital has a negative and statistically significant impact on income resilience, while both physical and financial capitals have a negative and statistically significant impact on employment resilience. Human capital has been found to have a mixed impact on both income and employment resilience.

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CHAPTER I

INTRODUCTION

1.1 Background and Purpose

Oklahoma has exhibited distinct climate periods attributable to natural variability in the last 100 years, from the decadal-scale droughts of the 1910s, 1930s and 1950s to an extended period of abundant precipitation during the 1980s and 1990s.

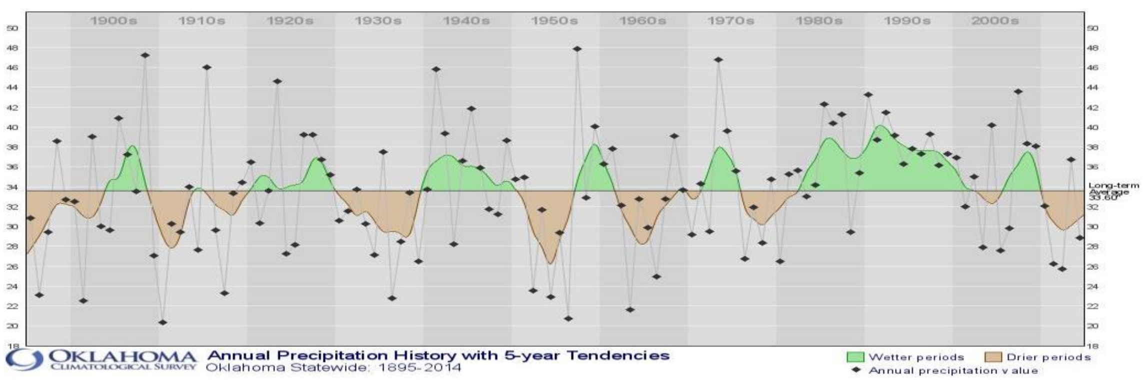

Figure 1: Oklahoma annual precipitation history

Due to Oklahoma’s social and economic vulnerability to climate variability, learning to adapt to nature’s extremes such as drought now will bring benefits in reduced economic losses, regardless of the future trajectory of climate change. Taking drought into consideration as the indicator of climate variability in Oklahoma, the purpose of this research is to find out the socio-economic factors which contribute to Oklahoma’s economic resilience to extreme climate variability.

Regional development policy mainly focuses on economic growth measured as growth in population, employment and or income. Policy makers try to find out and implement the best possible policies or instruments to accelerate regional economic growth. However, unexpected natural or economic shocks sometimes negatively impact regional economic growth. Economic resilience minimizes this negative impact on economic activities and enables the region to recover quickly and return to its original state. For this reason, understanding regional economic resilience to such shocks is increasingly becoming a significant policy issue.

Moreover, the different types of responses by different regions or communities to any regional and national level shocks has extended the analysis of regional macroeconomic analysis from a narrowed focus on growth to one which covers the notion of economic resilience as well (Hill, Wial, and Wolman, 2008; Pike, Dawley, and Tomaney, 2010; Han and Goetz, 2013). Widely used in the ecological, physical, engineering, psychological and organizational sciences, the notion of 'resilience' has very recently created interests among regional analysts and spatial economists (Martin, 2012). See Reggiani, De Graaff, and Nijkamp, 2002; Hill et al., 2008; Pendall et al., 2010; Pike et al., 2010; Simmie and Martin, 2010; and Han and Goetz, 2013 for specific examples. Resilience is becoming a popular and vital tool for regional economic analysis because successive natural and environmental shocks have troubled local communities in different parts of the world (Pike et al., 2010; Martin, 2012). Destructive events ranging from the terrorist attack on the World Trade Center complex in New York City in 2001 to Hurricane Katrina's impact on several states near the Gulf of Mexico in 2005 has encouraged policy makers and researchers to study this notion (see, for example, Foster

2007; Hill et al. 2008). The possibility of incorporating three important aspects of regional change including ecological, economic and social into a single phenomenon makes this idea interesting to most researchers (Bristow, 2010; Pendall et al., 2010). Several other factors identified by Christopherson, Michie and Tyler, 2010 have also made the regional development researchers include 'resilience' in their research interest, such as the questions (1) What does a resilient community look like? (2) Why are some communities less impacted by a shock than others? (3) Why do some communities recover quickly from economic shocks?

To answer the above mentioned questions, it is necessary to know what characteristics of a region lead to economic resilience. However, there is no straightforward answer to this question because of the feedbacks between the social, economic and environmental systems (Holling, 2001). A useful framework to assess community resilience can be derived from the community capitals framework literature (Miles and Chang, 2008). Community capitals represent the resources a community possesses or invests in to achieve sustainability. Community Capitals Framework (CCF) proposed by Emery and Flora (2006) divide community capitals on which a community relies (see Table 1) into seven categories: social, cultural, human, political, physical, financial, and natural.

Since community members depend on community resources and capitals throughout the process of developing community resilience, the community capital framework (CCF) offers an effective way to measure communities' economic resilience (Magis, 2010).Communities face long term stability challenges when they lack some of these capital assets (Flint, 2010). Therefore, it can be said that larger stocks of these resources can contribute to a community's resilience to any shock (Flint, 2010). However, it is difficult for researchers and policy makers to determine which types of capital contribute most to the economic resilience of a community, particularly when resources are scarce and /or options are limited.

Miles and Chang (2008) argue that a resilient community is one that does not experience a serious reduction or drop in community functions when any major or minor disturbances occur and, in the case of a drop, it recovers to a similar or better level of activities in a reasonable time period. According to estimates by researchers at Oklahoma State University, Oklahoma realized more than $400 million in losses due to the drought in 2012.The estimated total $426,125,520 in losses included crops and livestock, wildfire property losses, and municipal costs. Adding to the previous year's $1.6 billion setback, Oklahoma has suffered more than $2 billion in drought-related agricultural losses since 2011(Oklahoma Water Resource Center).Therefore, it is vital for policymakers to focus on improving the economic resilience of Oklahoma to climate variability such as drought. The community capital framework (CCF) gives us this opportunity to analyze a community's development efforts towards economic resilience by identifying the elements in each capital (stock), the types of capital invested (flow), and the interactions and impacts across different capitals (Emery and Flora, 2006). Moreover, from past experiences it is observed that Oklahoma counties are prone to natural disasters including drought, wildfire, dust storms and rainfall anomaly. These hazards pose a great threat to a sustainable Oklahoma economy. Therefore, it is essential to know which of these community capitals can help Oklahoma communities be more resilient, and there by sustain or enhance community services. CCF offers a tool to identify the factors for a county’s resilience towards economic or natural disturbance by analyzing the community capitals available to that community. In this paper, this idea has been used for two reasons: (1) it is a mechanism for systemic evaluation which allows us to differentiate the outcomes of different development efforts in a community with or without certain types of capital and through changes in different capitals over time, and (2) it could be an effective tool for Oklahoma communities to properly identify the required capital investment, which would lead to selecting policies that influence the flow of appropriate assets and increase capital stocks in the state as a whole (Emery and Flora, 2006). Moreover, if a community’s critical services and capitals are not resilient to a severe economic or natural disturbance, the personal livelihoods in the community would be under great risk in the aftermath of any such disasters (Miles and Chang, 2008).

None of the elements in different capitals are fixed because change is a common phenomenon both in nature and society; therefore, community resilience comes through how the community members utilize different community capitals for sustainable community development in an environment characterized by variability and uncertainty (Magis, 2010). Moreover, to achieve a sustainable economy, community developers should make informed decisions. The challenge for decision makers is that policymakers should choose a policy from possible alternatives for a particular community or region. To select the most suitable policy for sustainable development, decision makers need to understand what would be the connected economic, social and environmental consequences of that policy in a community, because challenges towards sustainable development are mainly represented by global climate change, local climate variability, search for cheap energy, natural disasters, and resource depletion, etc. (Flint, 2010).

Although climate variability is a key aspect of climate change (Karl et al., 1995), most people discuss climate change as a long term process, even though they experience climate variability more often. As climate changes, there is high probability that climate variability will also change (Rind et al., 1989). Therefore, to understand climate change it is necessary for us to understand the changes in climate variability and extremes (Karl et al., 1995). Since Oklahoma is a state where climate variability is high and where past extreme climate events have afflicted most of the counties, Oklahoma counties are an appropriate unit of analysis to examine resilience to climate variability, as measured in terms of economic outcomes.

Historical data analysis depicts that the frequency of such extreme climatic events in a particular geographical area is relatively more dependent on any changes in the variability than in the mean of climate which is commonly used by researchers (Kartz and Brown, 1992). In addition, although Oklahoma is very prone to climate extremes such as ice storms, tornadoes, floods, drought, and wildfire, it is not well prepared to address these extremes (Riley et al., 2012). This is due to a lack of research on the impact of climate variability in Oklahoma and on how to minimize the losses during extreme climate variability. Climate variability has impact on several Oklahoma economic activities. For example, persistent, multi-year variations in annual precipitation and mean air temperature can influence agriculture and water resources management; such impact is greater in farm and tourism dependent counties. Since the frequency of such extreme climatic events depends on climate variability and Oklahoma counties have already suffered from several extreme climate events and huge economic losses, the question arises among policymakers: which characteristics of Oklahoma counties make Oklahoma more resilient to climate variability? In addition, although higher climate variability influences economic activities and put regional economies at risk, the knowledge on the recent behavior of this relationship is limited. This research fills this knowledge gap through measuring the economic resilience of Oklahoma to climate variability. Therefore, the main objective of this research is to examine the contribution of community capitals to economic resilience of Oklahoma under extreme climate variability. In this research, it has been hypothesized that community capitals play a vital role to make Oklahoma counties economically resilient to climate variability.

CHAPTER II

REVIEW OF LITERATURE

Empirical research on regional economic resilience is sparse due to (1) the presence of ambiguity and difference of views while defining regional economic resilience (2) difficulty of measuring it, and (3) absence of the knowledge of policy implications (see Christopherson et al., 2010; Pendall et al., 2010; Hudson, 2010). Moreover, due to these reasons, some economists even state their doubt in the notion of regional resilience (for examples, see, Hassink, 2010; Hudson, 2010; Pike et al., 2010). However, Reggiani et al. (2002) argued that resilience should be a key topic in regional economic analysis. He also states (1) the concept of resilience should be well defined, and (2) the study should cover not only ecological systems but also socio-economic systems because these systems could be seen under a single umbrella (Reggiani et al., 2002).

When the definition of resilience is concerned, Pendall et al. (2010) examined literatures from multiple disciplines including ecology, geography, psychology, political science, urban studies, disaster management, and economics to give a snapshot how of how these disciplines see resilience. They found several views of resilience in different disciplines, such as returning to pre-shock conditions known as engineering resilience, ability of people, regions or ecosystems to survive despite the negative impact of a shock, known as ecological resilience. They also found papers arguing resilience from a complex systems viewpoint. Among these three perspectives, engineering and ecological resilience are applied in most of the empirical research on regional economic resilience (see for example, Fingleton et al., 2012). Moreover, according to Pendall et al. (2010), despite the growing interest in systems with multi-equilibrium focusing on a single equilibrium dominates most of the fields such as psychology, disaster management, etc. Pendall et al. (2010) argue that although the concept of resilience poses the danger of fuzziness, this problem could be reduced by limiting space and time boundaries. They also conclude that resilience could be a vital tool to investigate regional changes when incorporating different types of regional stresses.

2.1 Defining Resilience

As a concept that has recently emerged in the field of social science or economics, resilience has no universally agreed upon definition, let alone in regional studies (Simmie and Martin, 2010). According to most dictionaries, resilience means the power or ability to return to the original form, position, etc., after being affected by an adverse incident. For example, these definitions can be found online: (1) “ability to improve quickly after being hurt or being ill” by Cambridge dictionary; (2) “the ability of a substance or object to spring back into shape; elasticity” by Oxford dictionary. This definition originates from the Latin root *resilire* which means ‘to leap back or to rebound’. Table 1 illustrates, from the literature review, some of definitions made by different authors:

Table 1: Definition of resilience by authors

Author	*Definition*
Holling, 1973	'measure of the persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables (page 14).'
Pimm, 1984	Resilience is the speed with which a system returns to its original state following a perturbation.
Briguglio et al., 2006	Economic resilience can be defined in many ways, but here the term is used to refer to the ability to recover from, or adjust to, the negative impacts of external economic shocks.
Foster, 2007	Regional resilience is the ability of a region to anticipate, prepare for, respond to and recover from a disturbance (page 14).
Rose and Liao, 2005	Economic resilience refers to the ability or capacity of a system to absorb or cushion against damage or loss
Cutter, et al., 2008	Resilience is defined as a system's capacity to absorb disturbance and re-organize into a fully functioning system.
Hill et al., 2008	Regional economic resilience is the ability of a region to recover successfully from shocks to its economy that either throw it off its growth path or have the potential to throw it off its growth path but do not actually do so.
Hudson, 2010	A resilient system is an adaptive system that adjusts and responds in ways that do not damage or jeopardize effective functioning, remaining on an existing developmental trajectory or making the transition to a new one.
Martin, 2012	The idea of resilience' refers to the ability of an entity or system to 'recover from and position elastically' following a disturbance or disruption of some kind.
Han and Goetz, 2013	Resilience is defined as the capacity of a system to recover its functions and structure after an internal or external shock.

2.2 Three Concepts of Resilience

Although resilience is a common concept in many fields such as physics, psychology, ecology, the notion of resilience has recently been applied in social sciences including regional economies (Simmie and Martin, 2010; Hudson, 2010). Although this concept is gaining popularity because of its' capacity to incorporate the ecological with the socio-economic dimensions of regional change (Bristow, 2010; Pendall et al., 2010), some scholars argue about its' usefulness due to the presence of the concepts like lock-in and path dependence (Hassink, 2010; Pike et al., 2010). The present literature leads us towards analyzing several dimensions of regional resilience (Hudson, 2010). As an interdisciplinary term, 'resilience' has been defined differently across various disciplines.

However, to be analytically useful, at least three but not unrelated definitions could be drawn from various literatures that refer to resilience ideas (Martin, 2012).

How do regional economies respond to any recessionary shock? Do they return back to their original state or take a new growth path? According to Fingleton et al. (2012), to answer these questions, the “plucking model” of business fluctuation by Friedman (1993) could be a good start. In general, every economy tends to be around a trend value which varies over time. Milton Friedman argued (first in 1964; reprinted in 1969; revisited in 1993) that output or employment varies along a string or ceiling value which is plucked downward occasionally by recessionary or other shocks (Fingleton et al., 2012; Friedman, 1993).

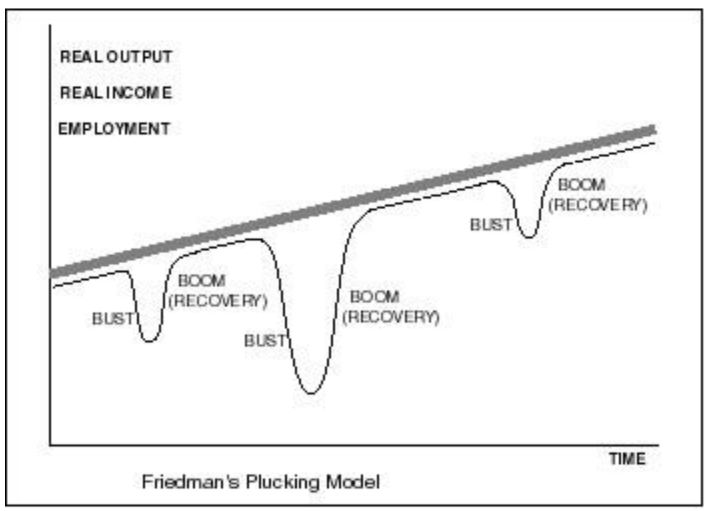

Figure 2: Friedman’s Plucking Model

If we imagine the graph in figure 2 above for any particular region, we can see that the trend of the economy’s growth path is slightly upward. This represents two things: (1) that the output of employment has a gradually rising upper limit usually determined by the different types of community capitals, and (2) that the change per unit of time in the economic growth path is constant and the fluctuations below the growth path represent temporary declines in the economic output or employment caused by irregular shocks in the economic system (Fingleton et al., 2012).

From this "plucking model" idea we get the first and perhaps most common definition of 'resilience' which is known as engineering resilience. Engineering Resilience, first named by the ecologist Holling (1973), is related to the ability of a regional economy to withstand against the negative impact from any shock or to retain both its core economic functions despite the presence of any perturbation in the system and the ability of a regional economy to return back to its pre-existing state following a shock (Foster, 2007, Simmie and Martin 2010; Hudson, 2010; Hill et al., 2012). Under this concept of economic resilience, regional systems are assumed to be in 'equilibrium' before the shock; economic resilience, then, is defined as the stability of the system near its 'equilibrium' (e.g. Holling, 1973; Pimm, 1984; Walker et al., 2006). According to Martin, (2012), for instance, if two systems are affected by the same shock and both systems return to the pre-shock stage, the system which returns more quickly to its pre-shock 'equilibrium' state is deemed to be more 'resilient' than a system which takes longer to come back to its 'equilibrium' or steady state. The most important assumption in this definition is that, although a shock can throw an economy off from its equilibrium growth path, the system eventually returns back to that growth path (see figure 3 below) through its self-correcting forces and adjustments (Simmie and Martin, 2010).

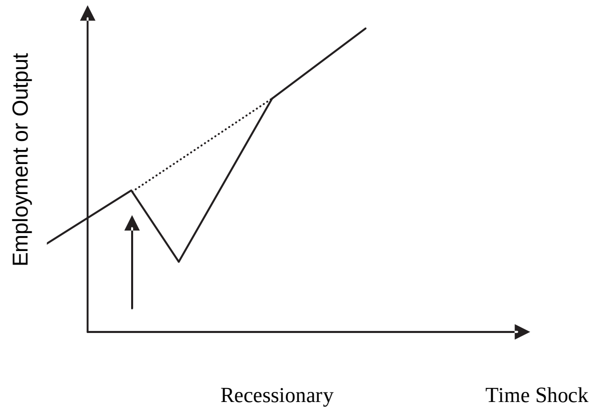

Figure 3: Impact of a recessionary shock on a region's growth path: region returns to pre-shock growth trend.

Drawing ideas from ecology, the second dimension of resilience is related to the ability of a system to remain on or return to a long run growth path in the face of an external shock (Hill et al., 2012). Holling (1973) called this notion 'ecological resilience'. Martin, (2012), explains this form of resilience as the ability of a system maintained by one set of reinforcing factors to tolerate disturbance without transforming into a system maintained by a different set of factors. Since this notion of resilience explains the role of shocks in forcing a system beyond its 'elasticity threshold' to a new domain, resilience is measured by the extent of perturbation that can be absorbed before the system changes from one state to another (Holling, 1973 ; Walker et al., 2006). According to Martin, (2012), a regional system has multiple stability domains under this concept, so the system may move to a different state in terms of its growth path when a system fails to absorb the magnitude of the shock. In this case, the size of the shock goes beyond the level of tolerance by that system and becomes unable to return to its former growth path. As a result the system will take an alternative growth path. Thus a greater ability of a system to absorb the perturbation of a shock, suggests greater resilience by the system (Martin, 2012). Martin (2012) also states it is possible to identify different, possible responses from a regional economic system after experiencing negative impacts from a recessionary shock on the economy's growth path (see figure 4 below).

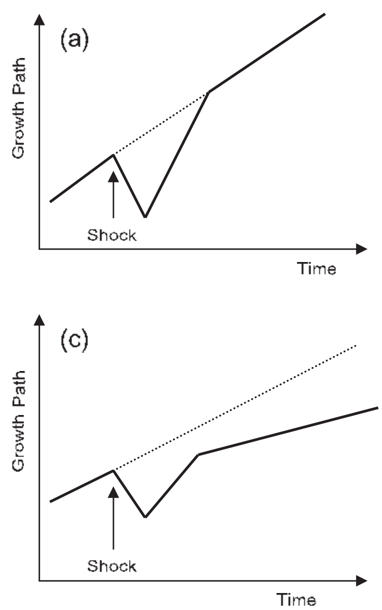

Figure 4: Responses of a Regional Economy to a Major Shock.

Figure 4 illustrates that (a) the return of a region to its pre-existing steady-state growth path following the shock (engineering resilience);(b) and (c) illustrate a region that fails to return to the former steady state growth path after the shock, but settles on inferior path; and (d) a region that recovers from the shock and assumes an improved growth path (Simmie and Martin, 2010).

The third interpretation of the notion of resilience, known as ‘adaptive’ resilience, derived from the theory of complex adaptive system (Martin, 2012). This notion of resilience is related to the long term adaptability of regional economic system (Simmie and Martin, 2010; Pendall et al., 2010; Pike et al., 2010). According to Martin, (2012), regional economic resilience can be seen as having the capacity to maintain an acceptable growth in output or employment over time in a regional economy by reconfiguring and adapting its structures such as firms, industries, technologies, institutions, etc. Table 2 represents the differences between the three definitions of resilience.

Table 2: Differences among thetypes of resilience

	Types of resilience		
	Engineering	**Ecological**	**Adaptive**
Focus on	System returns	System stability	System Capacity
Measurement tool	Speed and extent of recovery	Scale of shock absorbed	Continuation of core functions
Idea	‘Bounce back’	‘Distance from equilibrium’	‘Bounce forward’
Use in economics	Mainstream economics	Multiple equilibrium economics	Evolutionary economics

Source: Martin, 2012; Martin et al., 2013 and extended by author

The concept of equilibrium in economics is simple in calculation and widespread in practice. Krauss and Johnson (1974) argues that equilibrium analysis is worth teaching in the economics discipline for at least three reasons: (1) it is the center of economic theorizing and the solution of the different economic topics through general equilibrium analysis; (2) it reveals the interdependence of different elements of an economic system; (3) it is a mechanism within which several branches of economic theory can be related. In addition, despite the growth in interest in multi-equilibrium systems, the ‘engineering’ concept of resilience tends to dominate in the fields of psychology and disaster studies, both of which seek to understand why people, infrastructure and places recover from disturbances and also persists in the field of ecosystem studies (Pendall et al., 2010). In fact, this notion of engineering resilience represents a close relationship with the use of equilibrium in mainstream economics (Simmie and Martin, 2010). Moreover, Pendall et al., (2010) states that many regional characteristics resemble partial equilibrium phenomena such as regional growth in output and population. He also mentions that rates of unemployment, poverty or labor-force participation can be considered partial equilibrium phenomena. Since all these subjects offer significant interest for economic researchers and policy-makers, the single-equilibrium version of resilience offers several important ways to understand a region (Pendall et al., 2010). That is why; this research focuses on 'engineering resilience', following Han and Goetz (2013), to analyze the economic resilience of Oklahoma counties.

2.3 Types of Community Capital

This research proposes the use of the community capital approach as a framework to assess the economic resilience of Oklahoma counties because a community needs capitals to make a sustainable economy (Mayunga, 2007). Community capital is defined as anything that is tangible that a community requires for its existence or from which it benefits (Miles and Chang, 2008). Emery and Flora (2006) note seven types of capital that a community relies on including, social, cultural, human, political, physical, financial, and natural. These are summarized in Table 3, which shows the seven types of community capitals, their elements and how these community capitals contribute to community resilience.

2.3.1 Natural (N) Capital

Natural capital, sometimes known as the life support for ecosystem (Mohareb, Murray, and Ogbuagu, 2009), is the ecological assets within a region including environmental quality (e.g. soil, air and water quality), healthy ecosystems (wildlife habitat conservation, wildlife biodiversity), natural resources (minerals, wildlife and plants, landscape) that provides a community with critical goods and services (e.g. forests, fish stocks, aquifers). All forms of life depend on natural capital including human life; however, human activities are mostly accountable for the depletion of natural capital in stock and quality (Mayunga, 2007). Natural capital determines human actions in a particular geographical area or community because it sets limits or affords opportunities for the community (Flint, 2010). It is impossible for any community to achieve high levels of economic and social development without the continuous services provided by natural resources. Therefore, it is important for a community to have natural capital stock and in sufficient abundance to become economically resilient.

2.3.2 Physical (F) Capital

Physical capitals are crucial for any community to function properly (Mayunga, 2007). They are the human-constructed infrastructure that helps to produce other capitals including sewers and water systems, plants, machinery, transportation, electronic communication, soccer fields, housing (Flint, 2010). Physical capitals are also used as a catalyst for a flow of future income (Mohareb et al., 2009).

2.3.3 Human (H) Capital

Human capital is the skills and abilities of the local population to access and utilize the available resources in and outside of their community to achieve sustainable

Table 3: Types and elements of community capitals and their relationship to resilience

Types of capital	Elements of the capital	Contribution to resilience
Natural Capital	resources stocks, land and water, ecosystems, biodiversity, scenery, and other natural amenities	(1) sustains all forms of living things, (2) reduces the risk from natural disasters such as storms and floods (3) protects the environment through absorbing toxic trash, (4) provides multiple community benefits through healthy ecosystems, and possible economic development opportunities
Human Capital	population, education, health, youth, skills, knowledge/information, creativity, diversity in both types of groups	(1) increases knowledge and skills to understand community risks, (2) increases the ability to develop and implement new strategies, (3) increases the use of the skills and abilities of local people's critical thinking, innovation, problem solving, (4) increases initiative, responsibility and innovation, (5) increases diversity
Social Capital	trust, norms of reciprocity, networks across people and groups, cooperation, common vision and goals, leadership	(1) increases group work in the society, (2) makes finding partners for development projects easier, (3) provides better community cooperation in support of new businesses and entrepreneurship, (4) increases the chance to have increased local and non-local participation, (5) provides the opportunity to have more effective leaders, (6) facilitates more access to resources, (7) increases the chances to form more local strategic plans for development (8) depersonalizes politics, (9) increases the ability of individuals to accept alternate views/opinions
Physical Capital	buildings, housing, public facilities, business/industry, transportation infrastructure, telecommunications infrastructure and hardware, utilities	(1) provides communication and transportation facilities for businesses, (2) increases facilities for emergency evacuation, (3) increases safety, (4) reflects increased community wealth and/or assets which could be used to offset natural disasters.
Political Capital	level of community organization through the use of government, ability of government to garner resources for the community, level of authority/ability to control specific situations	(1) increases the ability to secure resources for the community through elected officials, (2) helps community to implement new policies, (3) increases the participation of general people into community matters
Financial Capital	tax burden/savings, state and federal tax monies, philanthropic donations, grants, contracts, regulatory exemption, investments, reallocation, loans, poverty rates	(1) supports diverse and vital economic activities (2) helps to increase other capitals (3) provides instruments for business expansion (4) helps to sustain economy during short term loss (5) gives confidence for new entrepreneurs to implement their ideas (6) serves as a proxy for productivity
Cultural Capital	values, heritage recognition, traditions and celebrations	(1) helps to increase certain businesses (e.g. tourism and entertainment), (2) heritage, history, and ethnicity encourage development efforts, (3) celebrations open new opportunities for residents to engage one another and build relationships (4) commonly held values provide a vehicle for communication, cooperation to encourage activity

Source: adapted from Flora, Emery, Fey, and Bregendahl (2005) and Mayunga (2007)

development (Emery and Flora, 2006). In other words, human capital is the potential of individuals within a community that is determined by the genetics, environment, and other social factors. Since an adequate, skilled and trained work force is a fundamental requirement for economic development for any community, human capital including education, skills, health, self-esteem, and self-efficacy is probably one of the most important determinants of community resilience compared to the other forms of capital (Mayunga, 2007).

2.3.4 Financial (F) Capital

Financial capital is considered not only an important determinant of community resilience (Mayunga, 2007), but it is also an important aspect of a healthy economy because it is easy to measure (Flint, 2010). Financial capital refers to the distribution of resources from which community people can withdraw income or interest (Mohareb et al., 2009). Financial capital including savings, tax revenue, tax abatements, debt capital, investment capital, subsidies, grants, and philanthropy can help an economy to become resilient, sound, and diverse if it is fairly distributed (Flint, 2010).

2.3.5 Social (S) Capital

Social capital such as mutual trust among community members, collective identity, sense of sharing ideas about future, or working together, has a significant effect on various socio-economic issues (Shideler, 2004; Flint, 2010). This type of capital usually determines the degree of interactions among community people that help to strengthen a community's interaction and reliance upon one another (Flint, 2010). Social capital reflects the quantity and quality of social networks of a community, and it affects the level of resilience of that community because social capital provides internal and external linkages to facilitate the developmental process within the community (Mayunga, 2007).

2.3.6 Cultural (C) Capital

Cultural capital is related to how community people see the world, how they value different things, and how they think about alternative solutions of a problem (Flint, 2010). This capital is mainly derived through a community's norms, traditions, values, heritage, and local history (Mohareb et el., 2009). For instance, moral and spiritual thinking of a community, ways of knowing different things, language, ways of acting in different situations, and definition of what is problematic shape a community's cultural capital (Flint, 2010). Cultural capital helps to increase certain businesses e.g. tourism and entertainment and opens new opportunities for entrepreneurs to engage in new businesses. That is why cultural capital helps a community to become economically resilient. Through the sharing of common values, it also enables community members to quickly communicate and cooperate in unexpected situations.

2.3.7 Political (P) Capital

Political capital is the ability of a community to access power and organizations which allows individuals within the community to influence the rules and regulations that determine how the other community capitals would be distributed and how different community resources would be used (Emery and Flora, 2006; Flint, 2010). In other words, this capital sometimes refers to the ability of local community leaders and their ability to influence standards, enforce those standards, and most importantly engage local citizens to build connections among community people and increase local trust (Mohareb et el., 2009).

2.4 Response of Regional Economy

The literature depicts that after experiencing an employment shock, U.S. states and counties generally take eight or fewer years to return to their pre-shock unemployment rates but not to their pre-shock employment levels (Hill et el., 2012). For instance, Blanchard et al. (1992) examined how US states responded to employment shocks from the period 1950 to 1990. Analyzing the post-shock responses of US states over 40 years, they found that most of the US states returned to the pre-shock employment growth rates, but not their pre-shock growth path.

Feyrer et al. (2007) also did a county level study on one of the biggest employment shocks affecting the U.S. economy in the early 1980s, with a huge job loss in two main industries (about 500,000 in auto industry and 350,000 in steel industry). Out of 3,000 counties, about 140 counties were badly affected by this job loss. They found that the counties recovered within five years. They also found that counties with warm and sunny climates, large metropolitan areas were more likely to rebound. Among the climate variables, they found mean temperature and minutes of sunshine to be two significant predictors of growth. Population with four years of college education was a very strong contributor to the rebound, also.

Some authors have given a conceptual framework explaining how regional economies respond to shocks. Hill et al. (2008) mentioned three different kinds of regional responses after experiencing an economic shock. Some regions may return to their pre-shock growth path quickly. Some regions may hold their growth path and avoid a negative impact of any shock. Finally, some regions may be unable to return to or exceed their pre-shock growth path. He named these responses as economically resilient, shock-resistant, and non-resilient respectively.

Martin (2012) proposes four but interrelated dimensions to explain how regional economies respond to shocks: resistance, recovery, re-orientation and renewal. Resistance is the sensitivity of a regional economy to shocks. Recovery is related to the magnitude and time required to recover from the negative impact of shock. The third dimension identifies the extent to which the regional economy undergoes structural re-orientation and its implications for the region's output, jobs and incomes. The fourth aspect is related to the extent regional economies renew compared to the pre-shock growth path. Both Hill et al. (2008) and Martin (2012) mentioned two common aspects (1) how large of a drop a region experiences due to a shock, and (2) to what extent they recover. In this paper, we are going to apply these two aspects of drop and rebound.

2.5 Impact of Drought

From the literature on climate change impacts on economic growth, it has been found that the direct impact of drought on agriculture, other rural economic activities, and overall economic growth is significant. Statistics show that among the 16 Oklahoma industry sectors which contributed to GDP growth in 2013, agriculture including farming, forestry, fishing and hunting is the third contributor to Oklahoma GDP adding 0.33 percentage points to overall GDP growth, following the mining sector adding 2.48 and non-durable goods manufacturing, which added 0.47 (Evans, 2014). Drought directly affects agricultural activities in all counties of Oklahoma, but farm dependent counties are likely to be impacted more. Since Oklahoma counties experience frequent drought of different scales and drought induced losses, it is crucial for rural development decision makers to know what factors make these counties economically resilient to drought.

2.6 Factors Contribute to Economic Resilience

Several articles have identified variables that contribute to economic resilience. According to Martin (2012), regions with a diverse economy are often assumed to have more economic resilience; on the other hand, regions with a highly specialized economy tend to be more sensitive to cyclical downturns. He also mentioned manufacturing and construction industries tend to have more cyclical downturns from a given shock. Christopherson et al. (2010) also mentioned that a diverse economy aids resilience in his paper on economic resilience along with modern infrastructure (transportation, broadband, etc.), skilled work force and a supportive financial capital environment. Han and Goetz (2013) found several variables which contribute to economic resilience. According to their findings, US counties with greater population density and larger shares of younger (24-44 year olds) working age adults experienced smaller drops in per capita income following the "Great Recession" of 2007-2009. On the other hand, counties with larger shares of older workers experienced smaller drops, and higher rebounds –perhaps having more experienced workers. They also found that counties having larger portions of the population holding bachelor's degrees or more experienced a smaller drop during the recession and a higher rebound.

After reviewing the literature, it is clear that the community capital framework (CCF) not only covers most of the variables contributing to regional economic resilience, but it also gives additional variables to investigate. For example, the CCF framework identifies natural, physical, human, social, financial, cultural, and political capital which may contribute to a community's resilience.

CHAPTER III

METHODOLOGY

3.1 Data to Measure Drought

To measure drought, Plant Available Water (PAW) has been collected from Oklahoma Mesonet. Plant Available Water (PAW) is the amount of water stored in the soil and available for plant uptake. Daily data of PAW was available for from June 1, 1996 to December 31, 2012 at 116 Mesonet climate stations across Oklahoma. PAW daily data is available at three different depths of soil: from 0 to 10 inches, from 10 to 40 inches, and from 40 to 80 inches depth. To measure extreme climate variability causing drought, PAW at the first two soil depths is used, because plant available water at 40 to 80 inches depth are not important for the plants' growth. In this research, the daily total plant available water has been calculated as follows:

$$PAW_{TOTAL} = \theta_{0\text{-}10} + \theta_{10\text{-}40}$$

Where, PAW_{TOTAL} is total plant available water between 0 to 40 inches soil depth.

$\theta_{0\text{-}10}$ Plant available water between 0 to 10 inches soil depth.

$\theta_{10\text{-}40}$ Plant available water between 10 to 40 inches soil depth.

County level PAW_{TOTAL} is obtained using corresponding daily PAW_{TOTAL} data at 116 Mesonet climate stations across Oklahoma.

3.2 Measuring Climate Variability

Using the daily PAW_{TOTAL} data and following the method used by Lyons and Barnston (2005), another four variables have been calculated in order to calculate Weighted Anomaly Standardized Plant Available Water (WASPAW) index.

$$\mathrm{WASPAW}_{cN} = \sum_{t=1}^{N} \left(\frac{\mathrm{PAW}_{cmA} - \overline{\mathrm{PAW}_{cm}}}{\sigma_{cm}} \right) \left(\frac{\overline{\mathrm{PAW}_{cm}}}{\overline{\mathrm{PAW}_{cA}}} \right)$$

PAW_{cm} is the observed monthly total plant available water (PAW_{TOTAL}) for the m^{th} month in the A^{th} year in c^{th} county, and $\overline{\mathrm{PAW}_{cm}}$ is the long term monthly average over entire 1996-2012 periods total plant available water (PAW_{TOTAL}) for the m^{th} month at c^{th} county. $\sigma_{cm}$is the standard deviation of monthly precipitation for the m^{th} month in county c and $\overline{\mathrm{PAW}_{cA}}$is the mean annual total plant available water (PAW_{TOTAL}) in county c and year A.

The number of months, *N*, is equal to12 to capture annual plant available water anomalies. The WASPAW index measures plant available water anomalies relative to the typical plant available water level for a given month and year. One standard deviation from the mean of WASPAW has been chosen as a threshold level in order to identify extreme climate variability. The total number of months across counties above and below that threshold is counted.

3.3 Identifying Drought

Using Weighted Anomaly Standardized Plant Available Water (WASPAW) index, it becomes easy to identify extreme climate variability. A value of WASPAW index equal to or less than -1 is considered an indicator of an anomalously dry period and a value of WASPAW index equal to or greater than +1 is considered an anomalously wet period. In this research, the target is to identify the drought conditions which are represented by a WASPAW index value equal to or less than -1.

The total number of drought periods experienced by any particular county is presented in Appendix A. Using the above method, a total of 180 periods of droughts are identified; the specific counties and periods represented are listed in Appendix B. However, when a county faces consecutive drought events, it was recorded as a single drought event. A total of 42 observations were dropped because of this issue of reoccurring drought. For example, Beckham County experiences a consecutive drought from 2010 to 2012. However, only one observation is obtained.

3.4 Measuring Economic Resilience

According to Briguglio et al. (2006), economic resilience has been used at least three ways in the economic literature: (1) withstand the negative impact of a shock, (2) the ability to recover quickly from a shock, and (3) avoid the shock altogether. In this paper, the first two ways to measure regional economic resilience are used.

(1) Ability to withstand shocks: This attribute suggests that a region can minimize the adverse effect of a shock. This occurs when the regional economy has mechanisms to respond endogenously to negative shocks and reduce their effects. Therefore, the most resilient region would absorb the negative impact in such a way that the end effect on the regional economic activities is zero or negligible. For example, an educated and multi-skilled labor force could be an instrument to reduce negative impact; the region with an educated and multi-skilled labor force can address the negative external demand shocks in a particular sector in the economy by shifting its labor resources to another sector with stronger demand. Following Han and Goetz (2013), the "drop" of a region tells how much the employment, income or output declines after experiencing a shock. If the region has more withstanding ability against a shock, the economy will experience a small drop in its economic output or other growth variables. Hence, if a region experiences a small drop, then the region is considered to be an economically resilient region.

(2) Ability of an economy to recover: This attribute explains the ability of a region to bounce back to the original state after being adversely affected by a shock. A region will not have this ability if, for example, there is continuous large fiscal deficits or high rates of unemployment. On the other hand, discretionary policy tools, such as a strong fiscal policy allowing discretionary expenditure or tax cuts to mitigate the negative impact of the shocks, will enhance the ability of the region to recover quickly. In this way, a region can face an economic downturn and bounce back to its growth path. Following Han and Goetz (2013), the variable "rebound" describes the extent a region can recover in terms of its employment or output after experiencing a shock in a specific time period.

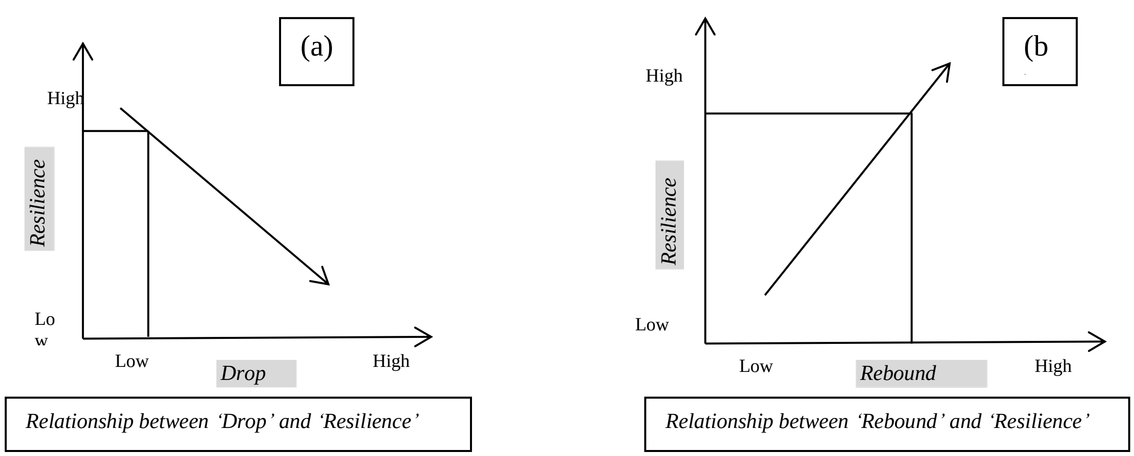

Figure 5: Relationship of drop and rebound with resilience

From above the figures, the negative relationship between "Drop" and "Resilience" (figure 5a is shown), so that as the magnitude of drop increases, the resilience decreases, and the positive relationship between "Rebound" and "Resilience" (figure 5b is shown), so that as the magnitude of rebound increases, the resilience also increases.

There is no straight forward method to combine these aspects of resilience into a single measure. In the literature review, it was found that authors have applied different methodological approaches to measure economic resilience, ranging from descriptive case studies to sophisticated statistical and econometrics models. Han and Goetz (2013) developed a method that is used in this paper to measure regional economic resilience in Oklahoma. Han and Goetz (2013) first calculated the drop and rebound measures and then measured economic resilience using drop and rebound measures. These concepts have been illustrated in Figure 6.

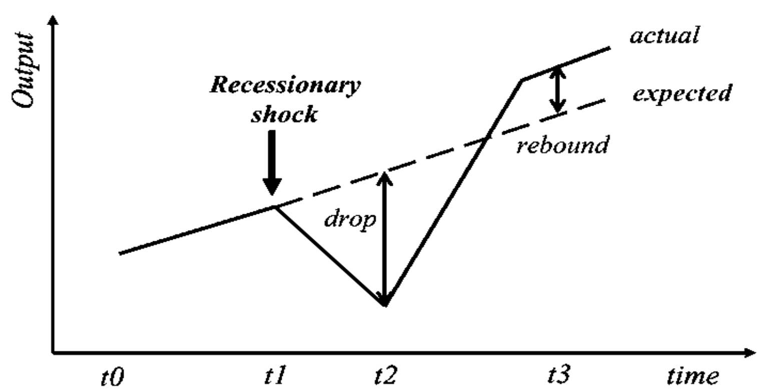

Figure 6: Regional economy changes to a major shock and concept of drop and rebound.

In the figure above, drop year (t_2) indicates when a county has its lowest income/employment/output following a shock, rebound year (t_3) indicates the year when a county gets out of drought, and Capital Year (t_1) indicates when all the community capitals and other explanatory variables have been collected for this research.

This means capital years are one year before the drop years. This is to eliminate potential endogeneity between the community capitals and economic resilience. In Appendix C, the table shows all the years for t_1, t_2, and t_3 for the county drought events in Oklahoma. The table shows that several counties have consecutive drought years. This caused a loss of some observations; for example, Beckham County experiences a consecutive drought from 2010 to 2012. Since only one value can be obtained for drop year (t_2) and rebound year (t_3), only one resilience value can be calculated from 3 drought periods.

Since income and employment are mostly negatively affected by drought, in this paper, per capita income and employment are used as Oklahoma economic indicators. To calculate the expected values for income and employment, first, a time trend regression is run separately for both income and employment.

Income or employment = f (year)

Then, the expected values for each county at the year t2 are calculated using the following formula:

$$\text{Expected}_{t2} = \alpha + \beta * t2$$

For example, the per capita income time trend regression coefficient for Adair county, α= -1095394 and β= 556.1854

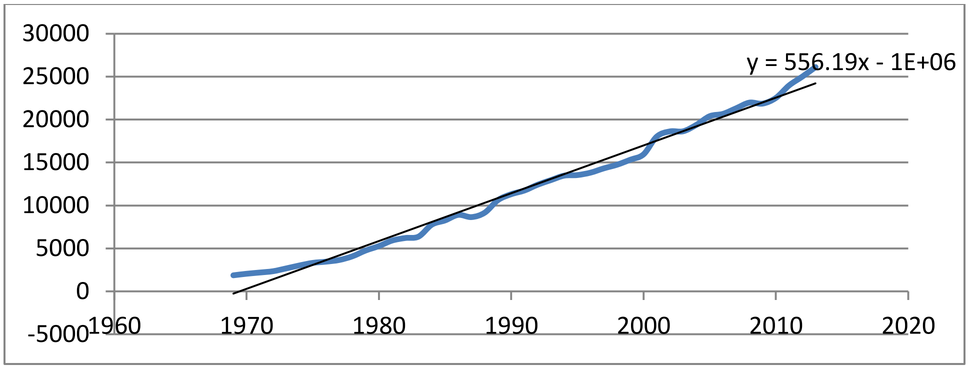

Figure 7: Adair county per capita income time trend

Therefore, expected per capita income in the year 2000 = -1095394 + 556.1854 * 2000 = 16976.8

And similarly, total employment time trend regression coefficient for Adair county, α= -280450.9 and β= 144.2314

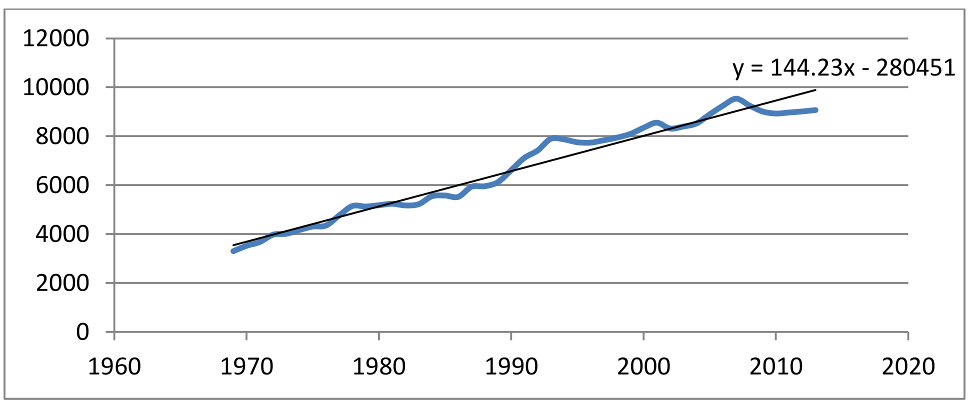

Figure 8: Adair county total employment time trend

Therefore, expected total employment in the year 2000 = -280450.9 + 144.2314* 2000 = 8011.9

And, likewise, the expected value for each county at the year t3 is calculated using the following formula:

$$\text{Expected}_{t3} = \alpha + \beta * t3$$

Here, t_1, t_2, t_3 will vary for each observed drought, and the corresponding data will be collected for each drought observed in each county.

Following Han and Goetz (2013), drop and rebound can be formulated as follows:

(1) *"Drop"* measures how much a county's economic activity changes after a shock at *t1*. This change can be calculated as the deviation of actual output from expected output at t_2:

$$\mathbf{Drop} = \frac{\text{Expected}_{t2} - \text{Actual}_{t2}}{\text{Expected}_{t2}}$$

(2) "*Rebound*" measures a system's recovery in terms of output by time t_3. Although the output in the economy may bounce back to the pre-shock level, the system could suffer from economic slowdown due to the shock, usually reflected in firm bankruptcies, salary reductions and unemployment (Han and Goetz, 2013). Rebound is calculated as follows:

$$\mathbf{Rebound} = \frac{\text{Actural}_{t3} - \text{Expected}_{t3}}{\text{Expected}_{t3}}$$

A greater rebound implies that the county has greater resilience, and it may be capturing the ability of the local economy to reorganize itself (in light of bankruptcies, salary reductions and/or available labor) in a more efficient and productive manner.

It is rare that a system will return to the exact pre-shock state because of the shock induced changes to its structure. A smaller drop and a greater rebound imply a sound economy and greater resilience. From the concept of resilience, minimizing the effect of a crisis and maximizing the benefits of reorganizing are both fundamental elements of resilience (Han and Goetz, 2013). Therefore, these concepts can be combined together to calculate the *Economic Resilience* of Oklahoma counties as:

$$\textbf{Economic Resilience} = \log\left(\frac{\text{Rebound} - \min(\text{Rebound}) + 1}{\text{Drop} - \min(\text{Drop}) + 1}\right)$$

This research has used the same method introduced by Han and Goetz (2013) for two reasons: (1) it is an easy method to calculate resilience under the "engineering" notion of resilience, and (2) it captures the impact on a system by comparing actual and expected output at different periods (Han and Goetz, 2013). Under this method of calculating economic resilience, if a county experiences a smaller decline and a greater recovery against a county impacted by a similarly scaled shock, then the former county is more resilient than the latter.

3.5 Resilience Model

In this research, model specification of a functional form for regional economic resilience and selection of explanatory variables are guided by economic growth literature. The main task of growth theory is to explain the variation of living standards across time and countries. The neoclassical growth model predicts that, under certain conditions, poor regions will grow faster than rich regions so that living standards across all regions will eventually be the same. A number of important drivers of economic growth have been suggested by the literature. Solow (1956) demonstrated the importance of physical capital and labor, and Mankiw et al. (1992) later added human capital (distinct from labor) as a major determinant of economic growth. In the years following this seminal work, a vast literature has expanded the traditional growth model to include other important factors. In this paper, specification of the model starts from the neoclassical growth model modified by Barro (1998).

(1) $D_y = f(y, y^*)$

Where Dy is the growth rate of per capita output, y is the current level of per capita output, and y* is the long-run or stead-state level of per capita output. In Barro's (1998) empirical model, per capita GDP growth rate is determined by the initial levels of capital (***y),***including both physical and human, and a set of environmental variables (***y*), which*** determine the steady-state growth rate of a local economy. Building on other literature, described briefly below, capital is expanded to include all the dimensions of community capital, as described earlier.

Rupasingha et al. (2000) proposed an extended version of Barro's general economic growth model as follows:

(2) $Dy_{t}, = F(Y_{t-1}, H_{t-1}, SC_{t-1}, R_{t-1})$

Where Dy_t is per-capita income growth, Y_{t-1} is initial per-capita income, H_{t-1} is initial human capital stock, SC_{t-1} is initial social capital stock, and R_{t-1} is a set of control variables.

Baum et al. (2003) added political capital to the growth model arguing that there are significant indirect effects of democracy on growth through public health and education. They also argue that democracy is an important determinant of the level of public services. Stiglitz (1998) mentions the importance of the financial sector for growth, which reduces the risk and uncertainty faced by both savers and investors; he argues that financial sector development is positively related to economic growth. Another important factor of economic production is natural capital, sometimes called ecological capital. Dalziel et al., (2009) argues that natural capital performs several important functions by providing resources for production (such as wood, coal, and crops), by acting as a sink for waste products (both from the process of production and the products themselves), providing a range of life support functions, or environmental services, such as flood or erosion control and climate stability, and contributing to human welfare directly through amenity services such as attractive landscapes. They also argue that, along with other capitals, cultural capital is also important because communities may require cultural capital to maintain their well-being, both in the present and for future generations.

In this paper, it has been assumed that counties that can minimize the economic loss during drought and can adapt to and leverage changing conditions to recover quickly are best positioned to attract and grow new businesses, and maintain expected income and employment growth. Therefore, the economic resilience model for Oklahoma has been derived from economic growth theory. From the literature review, the empirical model for economic resilience of Oklahoma can be specified as a function of a set of initial economic conditions, including community capitals, and other control variables to capture the contribution of different types of capitals to Oklahoma economic resilience. The results will allow us to identify important socio-economic characteristics and community capital which contribute to the regional economic resilience of Oklahoma. Therefore, we can outline the following conceptual relationship between the dependent and independent variables.

Economic Resilience = f (initial economic conditions, community capitals, and other controls).

3.5 Observations

As discussed earlier, unit of observations of this research is drought period. Using WASPAW index, a total of 180 drought periods identified across 77 counties of

Oklahoma. Some counties has more than one drought period. However, for consecutive drought periods, only one observation is obtained. For this reason, some observations have been lost, as discussed in the section 3.3 and 3.4. In the end, 138 observations have been obtained.

3.6 Data and Sources

To control for the initial regional economic conditions, four variables have been obtained including initial income and employment by county, population density and unemployment rate. Earnings and employment from three industries of Oklahoma have been obtained to control for specific sector contributions. Natural amenity index and highway mileage have been considered as proxies for natural capital and physical capital, respectively. Percentage of persons with a college degree (at least a 4 year degree), represents human capital; this will also be referred to as education attainment by county, represents human capital. Three age groups, including percentage of population between 25 to 44 years of age, percentage of population between 45 to 64 years of age, and percentage of population over 65 years of age have also been obtained as human capital. Dividend, interest & rent (DIR) income have been obtained as a proxy for financial capital along with transfer payments to persons to control for the impact of social benefits to Oklahomans. Social capital index, Arts, entertainment and recreation establishments, and voter registration data have been obtained as a proxy for social capital, cultural capital and political capital respectively. Table 5 shows the dependent variables, all the proxies for community capital and other control variables.

The main data sources for this research are Woods and Poole Economics, Inc. (CD-ROM), US Census, Economic Research Service (ERS), USDA, and the State of

Oklahoma official website (www.ok.gov). Woods and Poole Economics, Inc. is an experienced independent firm that specializes in long-term county economic and demographic projections. All county level income and employment data for 77 Oklahoma counties have been collected from Woods and Poole Economics, Inc.CD-ROM 2012 data set, including per capita income, employment, farm income, manufacturing & construction income, mining income, farm employment, manufacturing & construction employment, mining employment, government transfer payments, and DIR income. Total population by county and population by different age groups also were taken from the Woods and Poole Economics, Inc. CD-ROM. County level land area data was collected from U.S. Census Bureau's Geography Division based on the TIGER/Geographic Identification Code Scheme (TIGER/GICS) computer file. Population density was calculated by dividing total population by land area by county. Unemployment, natural amenity index, and percent of persons with a college degree (at least a 4 year degree), were downloaded from Economic Research Service (ERS), USDA website. Social Capital Index by Rupasingha et al. (2008) was downloaded from the Northeast Regional Center for Rural Development at the Pennsylvania State University website named "US County-Level Social Capital Data, 1990-2005" as a proxy for social capital. Arts, entertainment and recreation establishments data was collected from County Business Patterns (CBP), US Census as a proxy for cultural capital. Political capital, proxied by total voter registration by county, was collected from State of Oklahoma official website (www.ok.gov).Table 6 shows all the dependent and explanatory variables used in this paper.

Table 4: Variable description and summary

Dependent variables	Obs	Mean	Std. Dev.	Min	Max
Income Resilience *(PCIRESILIENCE)*	138	-.0385	.0087	-.0565	-.01013
Employment resilience *(EMPRESILIENCE)*	133	-.261	.637	-1.802	1.3503
Independent variables					
Initial Condition					
Initial per capita income *(INITIALPCI)*	137	26.99	5.59	14.15	41.96
Initial employment *(INITIALEMP)*	138	32.18	90.76	1.54	533.9
Population density *(POPDENSITY)*	133	40.53	60.24	1.35	476.82
Unemployment *(UNEMPLOYMENT)*	137	0.051	0.015	0.023	0.094
Industry Contribution					
% of Farm income *(FARMINCOME)*	138	0.076	0.114	- 0.09	0.453
% of Manufacturing & construction income *(MANCONINCOME)*	138	0.16	0.087	0.026	0.45
% of Mining income *(MININCOME)*	134	0.06	0.069	0.001	0.392
% of Farm employment *(FARMEMP)*	138	0.14	0.09	0.003	0.365
% of Manufacturing & construction employment *(MANCONEMP)*	138	0.127	0.055	0.046	0.28
% of Mining employment *(MINEMP)*	135	0.048	0.043	0.002	0.21
Natural Capital					
Natural amenity index *(NAIINDEX)*	137	0.54	0.93	-1.49	2.55
Physical Capital					
Highway millage *(HIGHWAY)*	136	0.203	0.062	0.058	0.343
Human Capital					
% of population between 25 to 44 age *(TO44AGE)*	137	0.246	0.023	0.202	0.301
% of population between 45 to 64 age *(TO64AGE)*	135	0.257	0.021	0.2	0.297
% of population over 65 age *(OVER65AGE)*	138	0.158	0.031	0.091	0.223
% of persons with a college degree*(EDUATTAIN)*	135	0.158	0.048	0.066	0.288
% of population between 25 to 44 age with college degree *(TO44EDU)*	134	0.039	0.013	0.017	0.079
% of population between 45 to 64 age with college degree *(TO64EDU)*	133	0.04	0.012	0.015	0.07
Financial Capital					
% of Dividend, interest & rent income *(DIRINCOME)*	136	0.158	0.038	0.081	0.277
% of Transfer payments to persons *(TRANSPAY)*	138	0.229	0.06	0.099	0.393
% of population over 65 agehaving dividend, int. income *(OVER65AGE)*	138	0.026	0.01	0.011	0.057
Social Capital					
Social Capital Index *(SKINDEX)*	135	-0.44	0.765	-1.79	1.7
Cultural Capital					
Arts, entertainment and recreation establishments *(AERES)*					
Political Capital	138	0.275	0.169	0.00	0.885
Voter registration *(VORERREG)*	134	0.586	0.095	0.155	0.838

3.5 Specification of Income Resilience Equation and hypothesis

Based on the theory discussed above in section 3.4, the following OLS regression model has been specified for income resilience:

$$PCIRESILIENCE_{c,t} = \beta_0 + \beta_1\, INITIALPCI_{\,c,t\text{-}1} + \beta_2 POPDENSITY_{c,t\text{-}1} + \beta_3 FARMINCOME_{c,t\text{-}1} + \beta_4 MANCONINCOME_{c,t\text{-}1} + \beta_5 MININCOME_{c,t\text{-}1} + \lambda_1\, NAINDEX_{c,t\text{-}1} + \lambda_2 HIGHWAY_{c,t\text{-}1} + \lambda_3 TO44AGE_{c,t\text{-}1} + \lambda_4 TO64AGE_{c,t\text{-}1} + \lambda_5 OVER65AGE_{c,t\text{-}1} + \lambda_6 EDUATTAIN_{c,t\text{-}1} + \lambda_7 TO44EDU_{c,t\text{-}1} + \lambda_8 TO64EDU_{c,t\text{-}1} + \lambda_9\, DIRINCOME_{c,t\text{-}1} + \lambda_{10} TRANSPAY_{c,t\text{-}1} + \lambda_{11} OVER65\_DIRIN_{c,t\text{-}1} + \lambda_{12} SKINDEX_{c,t\text{-}1} + \lambda_{13} AEREST_{c,t\text{-}1} + \lambda_{14} VOTERREG_{c,t\text{-}1} + \varepsilon_t$$

Han and Goetz (2013) found a negative and statistically significant relationship between per capita income and income resilience, which is supported by neo-classical theory since diminishing returns to capital explain that poor regions grow faster relative to the rich regions. This is known as “beta” convergence. Since counties with large initial per capita income are involved in maximum economic activities and thus expected to have a greater negative impact on economic activities by drought than that of counties with low initial per capita income, a negative relationship is expected for initial per capita income.

Population density has been included into the model to investigate whether there is any linear relationship between income resilience and population density. The assumption here is that a large population density creates a large market which attracts investor, bringing capital, technology and other factors of production that drive growth into the economy. Moreover, the existence of highway attracts firm owners and labor migrants in that region. For this reason a positive relationship is expected between income resilience and population density.

To control for the economic base of the counties, three variables including percentage of total personal income from farming, manufacturing and construction, mining have been included in the income resilience model. Since agriculture is most vulnerable to climate variability, a negative sign is expected for this sector. In addition, many counties of Oklahoma depend on mining-led export earnings. Due to the wide geographic distribution of mining operations, the extreme climate variability tends to have a complex impact on mining industry. Climate variability affects the stability and effectiveness of infrastructure and equipment usage, environmental protection and site closure practices, and the availability of water and transportation routes. For these reasons, a negative sign is expected for this sector. On the other hand, since manufacturing & construction earnings are not directly affected by climate variability, the impact of these sectors on Oklahoma income resilience is unknown.

Natural amenity index (*NAINDEX)* was developed and measured by USDA Economic Research Service (ERS) researchers. The natural amenity index has been constructed from six measures of climate, topographic variation and water area, all relatively permanent features of an area unlikely to be affected by local economic activities or human settlement. These measures are warm winter, winter sun, temperate summer, low summer humidity, topographic variation, and water area. These regional indicators were combined into a scale by summing standardized scores, which means that each indicator was given equal weight. The main advantage of using the natural amenities index is it allows one to refer to a region as having higher or lower natural amenities without having to consider six natural capital measures separately. Since natural capital positively influences economic activities and, retirees tend to move to high-amenity areas, a positive relationship is expected between natural amenity index and income resilience.

Highway mileages have significant impacts on local population and economic growth. Highway infrastructure is considered a physical input into the production process, so that a positive relationship between highway mileage and income resilience is expected.

Since different age groups have different needs and productive capacities, a region's economic characteristics will likely change as its population ages. This research also examines these effects on economic resilience. In order to control for different age groups, total population has been divided into 4 distinct groups, among which three groups have been included into the regression equation. Variables including percentage of population between 25 to 44 years of age, percentage of population between 45 to 64 years of age, and percentage of population over 65 years of age have been included in the income resilience model to control for age specific impact on income resilience of Oklahoma. Since first the two groups comprise the working population, a positive impact on income resilience is expected from both the percentage of population between 25 to 44 years of age and percentage of population between 45 to 64 years of age. In addition, nearly all Oklahoma residents age 65 or older receive Social Security, retirement or other unearned income. According to old age, survivor and disability insurance beneficiaries by State and County (OASDI, 2013), over 18% of all people received Social Security benefits in Oklahoma, and 92% of those ages 65 and older in 2012. In 2012, Oklahoma residents received $9.7 billion dollars from Social Security. Every $1 dollar of Social Security received in Oklahoma generates $1.84 of economic output (OASDI, 2013). According to the American Association of Retired Persons (AARP) Public Policy Institute (2013), spending by social security beneficiaries on goods and services generates

$16.9 billion in economic output for Oklahoma. For this reason, a positive relationship between percentage of population over 65 years of age and income resilience is expected.

In the growth literature, education attainment is positively related to economic growth. However, if most jobs created in a region do not require high educational attainment, then it could be a negatively related to economic growth; there is no incentive to increase educational attainment if it is not rewarded. Han and Goetz (2013) found a positive relationship between education attainment and economic resilience. Therefore, based on their findings, educational attainment is expected to have a positive relationship with Oklahoma income resilience.

The two interaction terms, *TO44EDU* and *TO64EDU*, represent the product of percentage of the population between 25 to 44 years of age and percentage of the persons 25 and older with a college degree and percentage of population between 45 to 64 years of age and percentage of the persons 25 and older with a college degree, respectively. This is an attempt to capture the educational attainment associated with each of these age cohorts specifically, which would serve as a proxy of each cohort's productivity. It is assumed that the impact of these two age groups with education attainment may have different impacts on Oklahoma income resilience and thus the signs are unknown for these two interaction terms.

Dividends, interest and rental earning is a component of individual economic well-being that is of particular importance to the older population. Stocks are a primary source of dividends; bank savings accounts are one source of interest earnings; and rental earnings include royalties from patents as well as net income from rental properties. Since dividends, interest and rental earning are passive income to Oklahomans and is less impacted by climate variability, it is expected to have a positive impact on income resilience.

Government transfer payments to households are expected to be negatively related to income resilience of Oklahoma counties. Gallaway & Vedder (2002) found a statistically negative relationship between government transfer payment and US economic growth. Therefore, it is expected to have a negative sign for transfer payment to income resilience.

The interaction term *OVER65_DIRIN* was formed by multiplying percentage of population over 65 years of age *(OVER65AGE)* with dividends, interest and rental income *(DIRINCOME)*. Oklahoma's population was about 3.8 million in 2012, with 534,000 being age 65 and older residents (OASDI, 2012). In addition, the income from dividend, interest, and rent shows an increasing trend. Therefore, it is worth including the interaction term to see the impact of the passive income of the aged people on Oklahoma income resilience. A positive relationship between percentage of population over 65 years of age having DIR income and income resilience is expected.

Social capital index was collected and developed by Rupasingha et al. (2008). The variables used to calculate this index are: total associations per 10,000 people, number of not-for-profit organizations per 10,000 people, census mail response rate for 1990, and vote cast for president in 1988 divided by total population of age 18 and over in 1990. The effect of social capital on economic growth is examined by several authors and has been found a positive effect on economic growth, so a positive sign is expected for social capital index.

Per capita art, entertainment and recreational establishments across Oklahoma is a proxy for cultural capital. A positive sign is expected for this variable because cultural capital supports growth in tourism-based industries, industries serving retirees, and industries employing the creative class in Oklahoma. Moreover, thousands of people visit attractive rural areas rich in natural amenities to camp, ski, bike, hike, boat, or fish. For this reason, a positive sign is expected for this variable.

Total voter registration by county is a proxy for political capital. Voter registration is an important vehicle of political participation which directly promotes community empowerment. A greater number of people exercising their right to vote illustrates that the residents have more influence over allocation and development of community resources. A positive correlation is expected between this variable and the resilience measures.

3.6 Specification of Employment Resilience Equation

To keep the analysis simple, the proxy variables for community capital used in income resilience equation have been kept the same for the employment resilience regression equation. This specification is constant with the existing literature of economic growth. The employment resilience equation for this research is:

$$EMPRESILIENCE_{c,t} = \beta_0 + INITIALEMP_{c,t-1} + \beta_1 UNEMPLOYMENT_{c,t-1} + \beta_2 FARMEMP_{c,t-1} + \beta_3 MANCONEMP_{c,t-1} + \beta_4 MINEMP_{c,t-1} + \lambda_1 NAINDEX_{c,t-1} + \lambda_2 HIGHWAY_{c,t-1} + \lambda_3 TO44AGE_{c,t-1} + \lambda_4 TO64AGE_{c,t-1} + \lambda_5 OVER65AGE_{c,t-1} + \lambda_6 EDUATTAIN_{c,t-1} + \lambda_7 TO44EDU_{c,t-1} + \lambda_8 TO64EDU_{c,t-1} + \lambda_9 DIRINCOME_{c,t-1} + \lambda_{10} SKINDEX_{c,t-1} + \lambda_{11} AEREST_{c,t-1} + \lambda_{12} VOTERREG_{c,t-1} + \varepsilon_t$$

According to the findings of Han and Goetz (2013), a negative relationship is expected between initial employment and employment resilience. Unemployment rate by county was used instead of population density in income resilience specification. It is important to know how unemployment as a lagging economic indicator affects economic resilience during drought. A negative relationship is also expected for this variable. For the other community capital proxy variables, the same relationships are expected except the percentage of population over 65 years of age. This variable is expected to have a negative relationship with employment resilience. Since this age group does not contribute to the labor force, it is expected to have a negative impact on employment resilience.

3.7 Estimation

Previous studies have used ordinary least squares (OLS) models to estimate the relationship between economic growth and socio-economic variables including different capitals. OLS estimation procedure has a strong theoretical justification for growth model estimation since a causal relationship is assumed between dependent and independent variables. Moreover, in this research, it is assumed that the independent variables are non-random since most of the growth models include different capitals as independent variables. As a consequence of this assumption, the community capitals, used as independent variables in this paper, are expected to be independent of the disturbance. Han and Goetz (2013) also used OLS to estimate economic resilience model. STATA 13 version has been used to estimate the economic resilience model.

CHAPTER IV

FINDINGS

4.1 Econometric Issues

It is important to note that both the models presented above in section 3.4 and 3.5 pose a few econometric concerns. The small sample size of 113 observations for income resilience and 112 observations for employment resilience is noteworthy. Although we started with 180 drought periods, some observations were lost at different steps of this research. First, when counties experienced consecutive drought years, some observations were lost because those drought periods only yielded one resilience value. Second, deleting outliers from explanatory variables caused some data loss. Finally, some independent variables had missing values, making those observations unusable. The regression models do not present omitted variable bias. The results of Ramsey RESET omitted variable bias test has been reported below for both income and employment resilience:

<u>Income resilience:</u>

Ramsey RESET test using powers of the fitted values of pciresilience
Ho: model has no omitted variables
F(3, 90) = 2.06
Prob > F = 0.1116

Since the p-value (0.1116 > 0.05) is not significant, we fail to reject the null hypothesis that model has no omitted variables.

Employment resilience:

Ramsey RESET test using powers of the fitted values of empresilience
Ho: model has no omitted variables
F(3, 91) = 0.44
Prob > F = 0.7234

Since the p-value (0.7234 > 0.05) is not significant, we fail to reject the null hypothesis that model has no omitted variables.

4.2 Findings from Income Resilience Regression

In terms of community capital, the OLS regression for Oklahoma income resilience (Table 6) shows that natural and financial capitals have a positive and statistically significant impact on Oklahoma income resilience. On the other hand, human and political capitals have a negative and statistically significant impact on Oklahoma income resilience. Physical, social, and cultural capitals have no statistically significant impact on Oklahoma income resilience. Initial per capita income is negatively and statistically related to income resilience; this indicates either that counties with high per capita income realized higher drops in their income than low per capita income counties, or that counties with low per capita income recovered faster. The latter is supported by the literature.

Unlike Han and Goetz (2013), who found population density had a statistically significant impact on economic resilience during economic recession, the impact of population density on Oklahoma income resilience is not statistically significant, although it has a positive sign. For Oklahoma, there is no evidence to support that population density has any impact on income resilience during drought in Oklahoma.

Table 5: Regression results for income resilience (dependent variable)

Independent variables	Standardize coefficient	t-statistic
Initial per capita income *(INITIALPCI)*	- 0.001 ***	-7.65
Population density *(POPDENSITY)*	0.000	0.49
% of Farm income *(FARMINCOME)*	- 0.0005	-0.06
% of Manufacturing & construction income *(MANCONINCOME)*	- 0.0008	-0.11
% of Mining income *(MININCOME)*	- 0.02 **	-2.21
Natural amenity index *(NAIINDEX)*	0.001 **	2.01
Highway millage *(HIGHWAY)*	- 0.008	-0.74
% of population between 25 to 44 age *(TO44AGE)*	- 0.105	-0.87
% of population between 45 to 64 age *(TO64AGE)*	- 0.32 **	-2.87
% of population over 65 age *(OVER65AGE)*	0.37 ***	3.95
% of persons with a college degree*(EDUATTAIN)*	- 0.57 **	-2.13
% of population between 25 to 44 age with college degree *(TO44EDU)*	0.50	0.72
% of population between 45 to 64 age with college degree *(TO64EDU)*	1.65**	2.53
% of Dividend, interest & rent income *(DIRINCOME)*	0.40 ***	4.55
% of Transfer payments to persons *(TRANSPAY)*	- 0.08 ***	-5.56
% of population over 65 age having dividend, int. income *(OVER65_DIRIN)*	- 2.13	-4.25
Social Capital Index *(SKINDEX)*	0.0002	0.21
Arts, ent. and recreation establishments *(AEREST)*	- 0.0009	-0.28
Voter registration *(VORERREG)*	- 0.016 *	-2.35
Constant	0.068	1.30
Number of obs 113 Model test F(19, 93) = 14.82 Adj R-squared 0.7009 Breusch-Pagan / Cook-Weisberg test for heteroskedasticity Ho: Constant variance, chi2(1) = 0.45, Prob > chi2 = 0.5008		

Significance level: *** = 1% or lower, ** = 5% or lower, * =10% or lower

When the contribution of a particular sector is concerned, all three sectors included in the model possess a negative sign, but only mining is statistically significant. Therefore, having a high percentage of income from the mining industry reduces community income resilience to climate variability.

Natural amenity index, an indicator of natural capital available in a county, increases income resilience to climate variability for Oklahoma. Therefore, the hypothesis that natural capital contributes to community income resilience cannot be rejected.

Comparing the impact of three age groups including percentage of population between 25 to 44 years of age, between 45 to 64 years of age, and over 65 years of age on income resilience, this research has found that percentage of population between 45 to 64 years of age is negatively and percentage of population over 65 years of age is positively related to income resilience. Both of these age groups are statistically significant. On the other hand, percentage of population between 25 to 44 years of age is negatively related but not statistically significant to income resilience. Here it is important to notice that only percentage of population over 65 years of age is positively related to income resilience. Since elderly people enjoy income which is not affected by drought (e.g. investment income or social security), their presence in a county contributes to income resilience during drought. On the other hand, since the other two age groups represent the labor force, and may experience substantial income loss related to the drought, their presence in a county negatively affects income resilience.

Education attainment, represented by the percent of persons with a college degree (at least a 4 year degree), alone has a negative impact on Oklahoma income resilience to climate variability. However, the interaction term of percentage of population between 45 to 64 years of age and education attainment depicts a positive impact on Oklahoma income resilience, while the interaction term of percentage of population between 25 to 44 years of age and education attainment is positive but statistically not significant. Since the magnitude of the parameter of the age specific term exceeds that of the educational attainment variable, one concludes that human capital from more experienced labor contributes to income resilience.

Dividend, interest, and rent income is positively and statistically related to income resilience. This is statistically significant at a 1% significance level. This evidence supports the hypothesis that financial capital contributes to Oklahoma economic resilience. Since dividend, interest, and rent income is not affected by drought, it perhaps makes a region economically resilient when income is concerned. However, government transfer payments, when isolated from total unearned income, are negatively related to Oklahoma income resilience and it is statistically significant.

Social capital index is positively related to income resilience but the relationship is not statistically significant. This suggests that the hypothesis that social capital contributes to Oklahoma income resilience is not correct.

Per capita arts, entertainment, and recreation establishments, as a proxy for cultural capital, is negatively related to income resilience but the relationship is not statistically significant. This leads to the rejection of the hypothesis that cultural capital contributes to Oklahoma income resilience.

Voter registration, a proxy for political capital, is negatively and statistically related to income resilience. This is the opposite relationship hypothesized, since it negatively impacts income resilience for Oklahoma. This is an unexpected result and needs to be investigated in future research.

4.3 Findings from Employment Resilience Regression

In terms of community capital, the OLS regression for Oklahoma employment resilience (Table 7) shows that only cultural capital, represented by per capita total arts, entertainment, and recreation establishments in the county, has a positive and statistically significant impact on Oklahoma employment resilience. On the other hand, physical and human capitals have a negative and statistically significant impact on Oklahoma income resilience. Natural, financial, social, and political capitals have no statistically significant impact on Oklahoma employment resilience.

Table 6: Regression results of employment resilience (dependent variable)

Independent variables	Standardize coefficient	t-statistic
Initial employment*(INITIALEMP)*	-0.002 **	-2.05
Unemployment*(UNEMPLOYMENT)*	-5.25***	-3.57
% of Farm employment*(FARMEMP)*	- .6 **	-2.31
% of Manufacturing & construction employment*(MANCONEMP)*	-0.079	-0.06
% of Mining employment*(MINEMP)*	-0.91	-0.55
Natural amenity index *(NAIINDEX)*	0.08	1.21
Highway millage *(HIGHWAY)*	-1.89 *	-1.43
% of population between 25 to 44 age *(TO44AGE)*	-1.14	-0.09
% of population between 45 to 64 age *(TO64AGE)*	-27.95 **	-2.28
% of population over 65 age *(OVER65AGE)*	-4.34	-0.86
% of persons with a college degree*(EDUATTAIN)*	-50.41 **	-1.76
% of population between 25 to 44 age with college degree *(TO44EDU)*	-5.99	-0.09
% of population between 45 to 64 age with college degree *(TO64EDU)*	197.91 **	2.78
% of Dividend, interest & rent income *(DIRINCOME)*	-6.52 **	-2.89
Social Capital Index *(SKINDEX)*	0.23	1.50
Arts, ent. and recreation establishments *(AEREST)*	0.80 **	2.29
Voter registration *(VORERREG)*	0.04	0.06
Constant	10.56 **	1.88
Number of obs 112 Model test F(17, 94) = 4.23 Adj R-squared 0.3310 Breusch-Pagan / Cook-Weisberg test for heteroskedasticity Ho: Constant variance, chi2(1) = 0.18, Prob > chi2 = 0.6722		

Significance level: *** = 1% or lower, ** = 5% or lower, * =10% or lower

Initial employment is negatively and statistically related to Oklahoma employment resilience; this indicates either that counties with higher levels of initial employment realized higher job losses than counties with lower levels of initial employment, or that counties with lower levels of initial employment recovered faster. The impact of unemployment on Oklahoma employment resilience is negative and statistically significant. This indicates that counties with high unemployment rates tend to be less economically resilient when employment resilience is concerned.

When the contribution of a particular sector is concerned, all three sectors included in the model possess a negative sign, but only farming is statistically significant with a greater marginal impact of -2.6, compared to manufacturing and construction sector with a marginal impact of -0.079 and mining with a marginal impact of -0.91. Therefore, it depicts that having a high percentage of income from farming industry reduces community employment resilience to climate variability.

It is also found that the natural amenity index, an indicator of natural capital available in a county, is positively related to Oklahoma employment resilience but statistically not significant. Therefore, the hypothesis that natural capital contributes to community employment resilience is rejected.

Comparing the impact of three age groups including percentage of population between 25 to 44 years of age, between 45 to 64 years of age, and over 65 years of age on employment resilience, this research has found that all age groups are negatively related to employment resilience. However, only percentage of population between 45 to 64 years of age is statistically significant with a greater marginal impact of -27.95 on employment resilience, compared to population between 25 to 44 years of age with a marginal impact of -1.14 and over 65 years of age with a marginal impact of -4.34.

Education attainment, represented by the percent of persons with a college degree (at least a 4 year degree), alone is negatively related to Oklahoma employment resilience to climate variability. However, the interaction term of percentage of population between 45 to 64 years of age and education attainment depicts a positive impact on Oklahoma employment resilience, while the interaction term of percentage of population between 25 to 44 years of age and education attainment is positive but has no statistically significant impact. Based on these findings, there is no clear evidence whether human capital contributes to employment resilience or not. Therefore, the hypothesis that human capital contributes to Oklahoma employment resilience is neither rejected nor supported. As with income resilience, the magnitude of the parameter estimate associated with the percentage of older persons with at least 4 year college education (197.91) exceeds that of educational attainment (-50.41) alone, so the marginal impact of higher education is likely positive.

Dividend, interest, and rent income is negatively and statistically related to Oklahoma employment resilience. This is statistically significant at 5% significance level. Therefore, this research rejects the hypothesis that financial capital contributes to Oklahoma employment resilience.

Social capital index is positively related to employment resilience but the relationship is not statistically significant. This leads to the rejection of the hypothesis that social capital contributes to Oklahoma employment resilience.

Per capita arts, entertainment, and recreation establishments, as a proxy for cultural capital, is positively related to employment resilience and the result is statistically significant at 5% significance level. This research fails to reject the hypothesis that cultural capital contributes to Oklahoma employment resilience.

Voter registration which is a proxy for political capital is positively related to employment resilience but not statistically significant. This leads to the rejection of the hypothesis that political capital contributes to Oklahoma employment resilience.

4.4 Summary of the findings

The following table shows the summary of the findings from both income and employment resilience regression equation. The table has been divided into parts including industry contribution and community capital contribution. The first part shows the impact of a particular industry presence in a county on income and employment resilience and the second part shows the contribution of seven types of community capitals on income and employment resilience for Oklahoma.

Table 7: Industry and Capital contribution to Resilience for Oklahoma

INDUSTRY CONTRIBUTION	**Impact on Income Resilience**	**Impact on Employment Resilience**
Farming Industry	**Negative**	**Negative** **
Manufacturing & Construction Industry	**Negative**	**Negative**
Mining Industry	**Negative** **	**Negative**
COMMUNITY CAPITAL		
Natural Capital	**Positive** **	**Positive**
Physical Capital	**Negative**	**Negative** *
Human Capital	**Mixed Impact**	**Mixed Impact**
Financial Capital	**Positive** ***	**Negative** **
Social Capital	**Positive**	**Positive**
Cultural Capital	**Negative**	**Positive** **
Political Capital	**Negative** *	**Positive**

*Note: *** Significant at 1%, ** significant at 5%, * significant at 10%*

From the above table, it can be said that all three industries examined in this research have a negative impact on economic resilience; however, the negative impact of farming industry on employment resilience and the negative impact of mining industry income resilience are statistically significant at 5% significance level. These findings indicate that during drought, the farming industry could suffer job losses and mining industry could suffer from income loss.

Natural capital has a positive impact on both income and employment resilience, though the relationship between natural capital and income resilience alone is statistically significant at 5% significance level. Physical capital also has negative impacts on both income and employment resilience, but it is only statistically significant for employment resilience at 10% significance level.

Human capital has a mixed impact on both income and employment resilience. Education attainment alone has a negative impact, but the interaction terms with different age groups have positive impacts on Oklahoma economic resilience. In addition, education attainment has a greater negative impact on per capita income than that of on total employment.

Financial capital has a positive impact on income resilience and a negative impact on employment resilience. This is the only capital which is statistically significant for both income and employment resilience, however, the sign is different for income and employment resilience. This might have occurred due to the choice of proxy (the percentage of personal income from dividends, interest and rent) for the financial capital. In other words, since DIR income is a passive income which is unaffected during drought, it has a positive impact on income resilience; however, it has a negative impact on employment resilience because it does not contribute to employment growth. For income resilience financial capital is statistically significant at 1% significance level, while for employment resilience financial capital is statistically significant at 5% significance level.

Social capital is positively related to both income and employment resilience; however, for both cases it is not statistically significant.

Cultural capital is negatively related to income resilience but statistically not significant; on the other hand, it is positively related to employment resilience with a marginal impact of 0.8 and statistically significant at 5% significance level.

Finally, political capital is negatively related to income resilience and statistically significant at 5% significance level; on the other hand, it is positively related to employment resilience but not statistically significant.

CHAPTER V

CONCLUSION

5.1 Policy Implications

From Table 9, it can be concluded that farming and mining industry negatively impact Oklahoma employment and income resilience respectively. Therefore, it is recommended for the farming and mining dependent counties of Oklahoma to take necessary precautionary actions against drought. It is encouraged that the landholders should manage their production system in harmony with the natural landscape to improve the landscape and decrease the severity of droughts. Livestock farmers are recommended to use rotational grazing systems to keep the lands greener for longer periods, which will help deal with long, dry times. It is also recommended to invest in three important community capitals for Oklahoma including natural, financial, and cultural capital. For example, as a natural capital investment, increasing drought awareness among community members, protection and enhancement of natural windbreaks (e.g., rows of trees between fields), monitoring groundwater sources for withdraw and recharge rates to insure adequate water supply exists for irrigation. **A**n income tax exemption for dividend payments from Oklahoma companies, similar to the current interest income exemption for interest earned on deposits in Oklahoma financial institutions, would encourage

Oklahoma residents to boost their investment and derive more income via this source. This would increase unearned income to older populations, which would be an income source unaffected by climate variation. As an investment in cultural capital, investments can be increased in urban greenspaces which can provide enormous recreation values, benefiting thousands of people in the county. They also offer significant potential for improvements in physical and mental health among the community members which in turn will reduce health expenditures and improve labor productivity.

5.2 Conclusion

This paper has several contributions to the empirical research of economic resilience. First, this paper investigates the economic resilience to drought. Previous empirical studies have been done on economic recessions. Drought and other environmental shocks affect both aggregate economic performance and social wellbeing. Likewise, drought events in Oklahoma were characterized by large livestock losses and severe socio-economic impacts on the communities living in Oklahoma. Second, a new type of data (e.g., plant available water) is used to identify drought in Oklahoma counties instead of relying on precipitation or temperature data. Plant available water is easy to calculate and provides accurate estimates of field capacity and water available for vegetation. Plant available water has been proven as a good indicator for drought. Third, to measure climate variability, monthly variation in plant available water is used rather than using conventional yearly averages. Using monthly averages captures more variation in the local climate. Finally, along with two major factors of production (physical and human capital), another five types of capital have been used to investigate the factors contributing to economic resilience for Oklahoma.

The main purpose of this research was to identify major community capitals that contribute to the economic resilience in Oklahoma during drought. This research successfully identifies several important community capitals which are important for Oklahoma to become more resilient during drought. Among seven kinds of community capitals, natural, financial, and cultural capital contribute to economic resilience for Oklahoma during drought.

Assessing the resilience of communities is a complex process as it involves the interaction of individuals, families, groups and the environment. There are many theoretical models which address this concept. Although a number of researchers promote the concept of capital as a means of assessing the potential of a community to demonstrate resilience to environmental shocks, they limit themselves to one or two capitals. This research opens the door for new research on economic resilience using seven community capitals. National level research can be done to see whether these findings are consistent or not. The findings from this paper can be applied for the states with similar climate condition like Texas or Kansas.

The attraction of using community capital approach depends on the ability to correctly measure the capital of a community, and hence its potential resilience to cope with future disruptive events. Since, in most of the cases, community level data is not available for all types of capital elements, it is still difficult for researchers to choose the right proxy for the seven community capitals. More research is necessary to explain appropriate proxies for the community capitals.

Empirical research on economic resilience is still in an infant stage. This research funded by the NSF EPSCoR project called ‘‘Adapting Socio-Ecological Systems to

Increased Climate Variability" is a great contribution to economic resilience research. Moreover, since researchers in this project are working together to advance the understanding of how socio-ecological systems can adapt sustainably to increased climate variability caused by a changing climate, this research findings will contribute to increase the understanding of relationship between socio-economic and ecological system. In addition, this research raises several new questions needing to be investigated in the future, such as why the negative relationship between political capital and income resilience exits or why there is a negative relationship between education attainment and economic resilience.

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APPENDICES

APPENDIX A

Number of Droughts by County

County	No. of Droughts
Adair	2
Alfalfa	3
Atoka	2
Beaver	4
Beckham	4
Blaine	2
Bryan	2
Caddo	3
Canadian	3
Carter	3
Cherokee	3
Choctaw	3
Cimarron	3
Cleveland	3
Coal	3
Comanche	3
Cotton	3
Craig	3
Creek	2
Custer	4
Delaware	3
Dewey	2
Ellis	2
Garfield	1
Garvin	2
Grady	3
Harmon	3
Harper	4
Haskell	2
Jackson	2
Jefferson	4
Johnston	1
Kay	2
Kingfisher	2
Kiowa	3
Latimer	2
LeFlore	3
Lincoln	2
Logan	2
Love	2
Major	2
Mayes	2
McClain	3
McCurtain	2
McIntosh	3
Muskogee	3
Noble	2
Nowata	2
Okfuskee	3
Oklahoma	4
Okmulgee	3
Osage	2
Ottawa	2
Pawnee	2
Payne	2
Pittsburg	4
Pontotoc	1
Pottawatomie	3

Pushmataha	1	Tulsa	2
Roger Mills	1	Wagoner	3
Rogers	2	Washington	1
Seminole	2	Washita	4
Sequoyah	2	Woods	2
Stephens	3	Woodward	1
Texas	4	**Grand Total**	**180**
Tillman	2		

APPENDIX B

Drought years by County

County	Drought Year
Adair	2005
Adair	2006
Alfalfa	2001
Alfalfa	2002
Alfalfa	2006
Atoka	2006
Atoka	2007
Beaver	2002
Beaver	2006
Beaver	2011
Beaver	2012
Beckham	1999
Beckham	2010
Beckham	2011
Beckham	2012
Blaine	2006
Blaine	2012
Bryan	2005
Bryan	2006
Caddo	2006
Caddo	2011
Caddo	2012
Canadian	2006
Canadian	2011
Canadian	2012
Carter	2006
Carter	2011
Carter	2012
Cherokee	2005
Cherokee	2006
Cherokee	2012
Choctaw	2005
Choctaw	2006
Choctaw	2011
Cimarron	2006
Cimarron	2008
Cimarron	2011
Cleveland	2005
Cleveland	2006
Cleveland	2011
Coal	2006
Coal	2011
Coal	2012
Comanche	2003
Comanche	2006
Comanche	2011
Cotton	2000
Cotton	2006
Cotton	2011

Craig	2000
Craig	2005
Craig	2006
Creek	2006
Creek	2012
Custer	2003
Custer	2006
Custer	2011
Custer	2012
Delaware	2006
Delaware	2011
Delaware	2012
Dewey	2003
Dewey	2006
Ellis	2006
Ellis	2012
Garfield	2006
Garvin	2005
Garvin	2006
Grady	2005
Grady	2006
Grady	2011
Harmon	2003
Harmon	2006
Harmon	2009
Harper	2002
Harper	2006
Harper	2011
Harper	2012
Haskell	2005
Haskell	2006
Jackson	2011
Jackson	2012
Jefferson	2000
Jefferson	2006
Jefferson	2009
Jefferson	2012
Johnston	2006
Kay	2006
Kay	2012
Kingfisher	2009
Kingfisher	2011
Kiowa	2003
Kiowa	2006
Kiowa	2011
Latimer	2005
Latimer	2006
LeFlore	2005
LeFlore	2006
LeFlore	2012
Lincoln	2005
Lincoln	2006
Logan	2006
Logan	2011
Love	2000
Love	2003
Major	2002
Major	2006
Mayes	2005
Mayes	2006
McClain	2005
McClain	2006
McClain	2012
McCurtain	1999
McCurtain	2000
McIntosh	1998
McIntosh	2005
McIntosh	2006
Muskogee	2006
Muskogee	2011
Muskogee	2012
Noble	2006
Noble	2012
Nowata	2006
Nowata	2012
Okfuskee	2006
Okfuskee	2011
Okfuskee	2012
Oklahoma	2006
Oklahoma	2008
Oklahoma	2010
Oklahoma	2011
Okmulgee	1997
Okmulgee	2006
Okmulgee	2012
Osage	2005

Osage	2006	Stephens	2006
Ottawa	2006	Stephens	2011
Ottawa	2012	Stephens	2012
Pawnee	2006	Texas	1997
Pawnee	2012	Texas	2002
Payne	2006	Texas	2006
Payne	2012	Texas	2011
Pittsburg	1998	Tillman	2006
Pittsburg	1999	Tillman	2012
Pittsburg	2000	Tulsa	2006
Pittsburg	2005	Tulsa	2012
Pontotoc	2005	Wagoner	2005
Pottawatomie	2005	Wagoner	2006
Pottawatomie	2006	Wagoner	2012
Pottawatomie	2012	Washington	2006
Pushmataha	1999	Washita	2003
Roger Mills	2006	Washita	2006
Rogers	2005	Washita	2011
Rogers	2006	Washita	2012
Seminole	2005	Woods	2006
Seminole	2006	Woods	2012
Sequoyah	2005	Woodward	2006
Sequoyah	2006		

APPENDIX C

Years by Oklahoma county indicating t1, t2, and t3

FIPS	Oklahoma County	Capital Year (t_1)	Drop Year (t_2)	Rebound Year (t_3)
40001	**Adair**	2004	2005	2007
40003	**Alfalfa**	2001	2002	2003
40003	**Alfalfa**	2005	2006	2007
40005	**Atoka**	2005	2006	2008
40007	**Beaver**	2001	2002	2003
40007	**Beaver**	2005	2006	2007
40007	**Beaver**	2010	2011	2012
40009	**Beckham**	1998	1999	2000
40009	**Beckham**	2009	2010	2012
40011	**Blaine**	2005	2006	2007
40011	**Blaine**	2011	2012	2013

40013	**Bryan**	2004	2005	2007
40015	**Caddo**	2005	2006	2007
40015	**Caddo**	2010	2011	2012
40017	**Canadian**	2005	2006	2007
40017	**Canadian**	2010	2011	2012
40019	**Carter**	2005	2006	2007
40019	**Carter**	2010	2011	2012
40021	**Cherokee**	2004	2005	2007
40021	**Cherokee**	2011	2012	2013
40023	**Choctaw**	2004	2005	2007
40023	**Choctaw**	2010	2011	2012
40025	**Cimarron**	2005	2006	2007
40025	**Cimarron**	2007	2008	2009
40025	**Cimarron**	2010	2011	2012
40027	**Cleveland**	2004	2005	2007
40027	**Cleveland**	2010	2011	2012
40029	**Coal**	2005	2006	2007
40029	**Coal**	2010	2011	2012
40031	**Comanche**	2002	2003	2004
40031	**Comanche**	2005	2006	2007
40031	**Comanche**	2010	2011	2012
40033	**Cotton**	1999	2000	2001
40033	**Cotton**	2005	2006	2007
40033	**Cotton**	2010	2011	2012
40035	**Craig**	1999	2000	2001
40035	**Craig**	2004	2005	2007
40037	**Creek**	2005	2006	2007
40037	**Creek**	2011	2012	2013
40039	**Custer**	2002	2003	2004
40039	**Custer**	2005	2006	2007
40039	**Custer**	2010	2011	2012
40041	**Delaware**	2005	2006	2007
40041	**Delaware**	2011	2012	2013
40043	**Dewey**	2002	2003	2004
40043	**Dewey**	2005	2006	2007
40045	**Ellis**	2005	2006	2007
40045	**Ellis**	2011	2012	2013
40047	**Garfield**	2005	2006	2007
40049	**Garvin**	2004	2005	2007
40051	**Grady**	2004	2005	2007
40051	**Grady**	2010	2011	2012

40057	**Harmon**	2002	2003	2004
40057	**Harmon**	2005	2006	2007
40057	**Harmon**	2008	2009	2010
40059	**Harper**	2001	2002	2003
40059	**Harper**	2005	2006	2007
40059	**Harper**	2010	2011	2012
40061	**Haskell**	2004	2005	2007
40065	**Jackson**	2011	2012	2013
40067	**Jefferson**	1999	2000	2001
40067	**Jefferson**	2005	2006	2007
40067	**Jefferson**	2008	2009	2010
40067	**Jefferson**	2011	2012	2013
40069	**Johnston**	2005	2006	2007
40071	**Kay**	2005	2006	2007
40071	**Kay**	2011	2012	2013
40073	**Kingfisher**	2008	2009	2010
40073	**Kingfisher**	2010	2011	2012
40075	**Kiowa**	2002	2003	2004
40075	**Kiowa**	2005	2006	2007
40075	**Kiowa**	2010	2011	2012
40077	**Latimer**	2004	2005	2007
40079	**Leflore**	2004	2005	2006
40079	**Leflore**	2011	2012	2013
40081	**Lincoln**	2005	2006	2007
40083	**Logan**	2005	2006	2007
40083	**Logan**	2010	2011	2012
40085	**Love**	1999	2000	2001
40085	**Love**	2002	2003	2004
40087	**Major**	2001	2002	2003
40087	**Major**	2005	2006	2007
40091	**Mayes**	2004	2005	2007
40097	**McIntosh**	1997	1998	1999
40097	**McIntosh**	2004	2005	2007
40093	**Mcclain**	2004	2005	2007
40093	**Mcclain**	2011	2012	2013
40095	**Mccurtain**	1998	1999	2000
40101	**Muskogee**	2005	2006	2007
40101	**Muskogee**	2010	2011	2012
40103	**Noble**	2005	2006	2007
40103	**Noble**	2011	2012	2013
40105	**Nowata**	2005	2006	2007

40105	**Nowata**	2011	2012	2012
40107	**Okfuskee**	2005	2006	2007
40107	**Okfuskee**	2010	2011	2012
40109	**Oklahoma**	2005	2006	2007
40109	**Oklahoma**	2007	2008	2009
40109	**Oklahoma**	2009	2010	2012
40111	**Okmulgee**	1996	1997	1998
40111	**Okmulgee**	2005	2006	2007
40111	**Okmulgee**	2011	2012	2013
40113	**Osage**	2005	2006	2007
40115	**Ottawa**	2005	2006	2007
40115	**Ottawa**	2011	2012	2013
40117	**Pawnee**	2005	2006	2007
40117	**Pawnee**	2011	2012	2013
40119	**Payne**	2005	2006	2007
40119	**Payne**	2011	2012	2013
40121	**Pittsburg**	1997	1998	2001
40121	**Pittsburg**	2004	2005	2006
40123	**Pontotoc**	2004	2005	2006
40125	**Pottawatomie**	2004	2005	2007
40125	**Pottawatomie**	2011	2012	2013
40127	**Pushmataha**	1998	1999	2000
40129	**Roger Mills**	2005	2006	2007
40131	**Rogers**	2004	2005	2006
40133	**Seminole**	2004	2005	2007
40135	**Sequoyah**	2004	2005	2007
40137	**Stephens**	2005	2006	2007
40137	**Stephens**	2010	2011	2012
40139	**Texas**	1996	1997	1998
40139	**Texas**	2001	2002	2003
40139	**Texas**	2005	2006	2007
40139	**Texas**	2010	2011	2012
40141	**Tillman**	2005	2006	2007
40141	**Tillman**	2011	2012	2013
40143	**Tulsa**	2005	2006	2007
40143	**Tulsa**	2011	2012	2013
40145	**Wagoner**	2004	2005	2007
40145	**Wagoner**	2011	2012	2013
40147	**Washington**	2005	2006	2007
40149	**Washita**	2002	2003	2004
40149	**Washita**	2005	2006	2007

40149	**Washita**	2010	2011	2012
40151	**Woods**	2005	2006	2007
40151	**Woods**	2011	2012	2013
40153	**Woodward**	2005	2006	2007

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